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TRADE AND DEVELOPMENT BOARD
Committee on Tungsten
Twenty-third session
Geneva, 18 November 1991
Item 6 of the provisional agenda

CONSIDERATION OF PROJECT PROPOSALS BY GOVERNMENTS AND INDUSTRY WHICH COULD BE SUBMITTED FOR POSSIBLE FINANCING UNDER THE SECOND ACCOUNT OF THE COMMON FUND FOR COMMODITIES

Addendum

Project proposals received by the UNCTAD secretariat

PROPOSALS BY THE PEOPLE'S REPUBLIC OF CHINA

Note: Project proposals received by the secretariat are reproduced as submitted without any change.

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Note by the UNCTAD secretariat

The Secretary-General of UNCTAD has received from the Ministry of Foreign Economic Relations and Trade of the People's Republic of China a communication dated 12 May 1991 transmitting three project proposals as follows:

I. Development of the ultra fine-grained WC and cemented carbide.

II. Development of the rare earth doped cemented carbide and its mechanism research.

III. Development of the new process for heat-treatment of cemented carbide and its application.

The communication includes the following comments on the proposals:

"The three project proposals, prepared by China Non-ferrous Metals Industry Corporation, envisage to improve the performance of cemented carbide, enhance competitive capabilities against substitution materials, increase working efficiency, and to reduce the cost of production. It is believed that these projects would be helpful to improve the overall situation of the tungsten industry."

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	Outstanding	*Excellent*	*Good*	*Adequate*	*Poor*
Presentation and readability	( )	( )	( )	( )	( )
Originality of ideas	( )	( )	( )	( )	( )
Wealth of information	( )	( )	( )	( )	( )
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Technical accuracy	( )	( )	( )	( )	( )
Quality of analysis, including objectivity	( )	( )	( )	( )	( )
Validity of conclusions	( )	( )	( )	( )	( )
Clarity of recommendations	( )	( )	( )	( )	( )
Comprehensiveness of coverage	( )	( )	( )	( )	( )

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PROJECT PROPOSAL 4 May 1991

Project Title

I. Development of the ultra fine-grained WC and cemented carbide

Beijing, People's Republic of China

A. AIM AND SIGNIFICANCE

With the rapid growth of world economy, it is required that the tool materials should have good TRS, high shock resistance and toughness in addition to high hardness. The ultra fine-grained cemented carbide with a combination of the above properties has obtained a wide application in information industry. As the ultra fine-grained cemented carbide cutting tools can be used in either slow or medium cutting speed under heavy load condition, they are excellent tool materials for filling the gap between high speed steel and cemented carbide.

Since 1970s, great efforts have been made in the world to develop ultra fine-grained cemented carbide, there are some achievements in this field. In 1989, Japan promulgated the first standard for ultra fine-grained cemented carbide (JISB 4053-1989). However, the grain size of WC used is 0.3-0.8 micrometre, while the grain size of WC in cemented carbide is 0.6 micrometre. Due to the comparatively large grain size, the combination of toughness and wear resistance is not adequately satisfactory with the maximum TRS of 3000 N/mm^2 and average TRS of 2000 N/mm^2.

According to results of latest research, the strength and hardness of cemented carbide can be effectively and harmoniously combined without an increase in hardness at the expense of the other or vice versa, provided that the average grain size of WC in cemented carbide is less than 0.3 micrometre. Up to now, there is little ultra fine-grained cemented carbide developed with grain size less than 0.3 micrometre in the world. It is known that the preparation of less than 0.3 micrometre grain size of WC and Co powder is a prerequisite for producing 0.3 micrometre grain-sized cemented carbide.

This project is estimated to be completed within 5 years (1992-1996). The ultra fine powders for this project, due to the unique process, shall not lead to dust pollution of the environment.

This project is aimed at adjusting the product structure, so as to improve the working condition for application of ultra fine-grained cemented carbide in South-east Asia. It is beneficial for the international tungsten industry to develop new highly tough cemented carbide for use under slow cutting speed.

B. OBJECTIVES AND OUTPUTS

1. Development objective

The overall objective of this project is to adjust product structure, and devlop ultra fine-grained cemented carbide.

2. Immediate Objective

2.1 Development of WC powder with average grain size $\leqslant$ 0.2 micrometre

2.2 Development of ultra fine grained cemented carbide with WC grain size $\leqslant$ 0.3 micrometre

Owing to the fact that it is rather difficult to develop $\leqslant$ 0.3 micrometre grain sized cemented carbide in consideration of the present production process and equipment, analytical and measuring technique, so the research shall be conducted in two steps:

	Average grain size	HRA	TRS, N/mm^2
First objective	$\leqslant$ 0.5 micrometre	91.5	-3000
Second objective	$\leqslant$ 0.3 micrometre	92.5	-3500

The ultra fine grained cemented carbides so produced will be superior to those with TRS of -2000 N/mm^2 and 3000 N/mm^2.

3. Outputs

3.1 Within 5 years after it is put into action, the project shall achieve the following output:

3.1.1 Development of cemented carbide with WC grain size of $\leqslant$ 0.3 micrometre for use in electronic and machinery industry, so as to improve the working condition for application of ultra fine grained cemented carbide in South-east Asia.

3.1.2 New technology for producing ultra fine grained cemented carbide can be shared by state members of the Committee on Tungsten, which is helpful to develop international tungsten industry, and to apply new highly tough cemented carbide to use under slow cutting speed.

3.1.3 About 1-2 grades of ultra fine grained cemented carbide are to be developed for the market to meet the domestic needs of special industry. It is expected to obtain substantial benefit.

3.1.4 This project is of help so as to establish an administrative system and development capacity for the R & D of new application of tungsten.

3.2 Output of 1992

3.2.1 Evaluation and agreement shall be made by the competent authorities and departments undertaking this project with regard to the production process, and technological route.

3.2.2 Drawing of the five-year research plan, covering development of ultra fine powders and its cemented carbide, product promotion and achievements evaluation.

3.2.3 At least 3 personnel shall have a good understanding of the progress and research direction of the project. In addition, they shall be able to conduct technical exchange at home and abroad.

3.2.4 Establishing and perfecting laboratory equipment so as to be capable of doing pilot experiment.

C. MAIN RESEARCH ACTIVITIES

This project is composed of the following activities:

--- Development of colloidal tungsten compound

--- Development of ultra fine WC

--- Research on passivation of ultra fine powder and its storing measures

--- Development of ultra fine-grained cemented carbide

--- Research on analytical and testing technique for determining grain size of fine powder and microstructure of cemented carbide

The overall objectives shall be realized within 5 years through a series of R & D, extensive technical exchange and cooperation.

The following activities shall be conducted during 1992-1993.

1. A detailed literature survey and extensive technical exchange shall be performed for each item of the project based on its respective objective, so as to work out respective research plan after analysis and evaluation.

1.1 Preparation of ultra fine WC powder

1.1.1 The raw material for the production of ultra fine WC shall be prepared by selection of either chemical precipitation, colloidal chemistry, addition of activating agent, or organic compound of metal tungsten;

1.1.2 The process parameters for the obtaining of ultra fine WC shall be optimized through selection of way of carburization and equipment;

1.1.3 Establishment of plasma laboratory through the designing and manufacturing of DC plasma generator;

1.1.4 Research on the process parameters for producing ultra fine WC powder by plasma furnace;

1.2 Research on passivation of ultra fine WC powder and its storing measures.

1.2.1 Passivation technique for stabilizing ultra fine WC powder;

1.2.2 Special protection technique for storing ultra fine powder;

1.3 Development of ultra fine-grained cemented carbide;

1.3.1 Selection of process for obtaining mixed ultra fine powders, and equipment;

1.3.2 Selection of grain growth inhibitor;

1.3.3 Compaction of mixed ultra fine powders, and selection of compaction method and its equipment;

1.3.4 Optimization of the process parameters for quick vacuum sintering under low temperature;

1.4 Research on the analytical and testing method for ultra fine powder and its cemented carbide;

1.4.1 Determination of grain size of ultra fine powder by BET, TEM, and x-ray diffractometer;

1.4.2 Determination of grain size of ultra fine-grained cemented carbide by metalloscopy and image analyzer;

2. Based on the executive plan of each item, and its process route, experimental preparation shall be made, and research shall be started on the required equipment and production process of the raw and subsidiary materials.

3. Development of the production process of tungsten compound

4. Partial experiment

5. Development of the ultra fine powder by DC plasma

During the next month following the approval of the project, the Ministry of Foreign Economic Relations and Trade of China and China National Non-ferrous Metals Industry Corp. together with Zhuzhou Cemented Carbide Works shall meet to finalize the task, objective and executive plan.

When the task is determined and finalized, the departments and personnel concerned shall, within 6 months, complete organization, practical plan, and literature survey; determine process route; conduct overseas technical exchange.

Detailed schedule and executive plan for 1992-1993 is attached; objective plan for 1994-1996 shall be worked out in the fourth quarter of the second year after the project has started, meanwhile a stage summary report for 1991-1993 shall be presented.

1992: Present investigating report and executive plan of the project
1993: Present a stage report on the development of ultra fine WC powder
1994: Achieve the first objective
1996: Present a report on the development of ultra fine-grained cemented carbide.

D PROJECT INVESTMENT AND EXPENDITURE BUDGET

This project is a rather difficult one from the point of technology, as it covers development of equipment, research on analysis and testing as well as production process and basic theory, so a total of $US 1.73 million is required:

1.	Input by the Second Account of the Common Fund	
1.1	Equipment	
	Low pressure HIP/vacuum sintering furnace	$US 750,000
	Energy dispersive (small angle) X-ray analyzer	$US 150,000
	50 kw DC plasma furnace	$US 300,000
	Infra-red vacuum drying furnace	$US 80,000
	Reaction spray equipment (RSV)	$US 150,000
	subtotal:	$US 1,430,000
1.2	Reagent, material (key materials and special reagent for structure testing and process research)	$US 80,000
1.3	Mission cost (project formulation, monitoring and evaluation)	$US 65,000
1.4	Duty travel (literature survey, selection of equipment, etc.)	$US 45,000
1.5	Miscellaneous (communications, etc.)	$US 30,000
1.6	Unpredictable (5%)	$US 80,000
	Total:	$US 1,730,000
2.	Investment by People's Republic of China	

Investment by the China National Non-ferrous Metals Industry Corp. includes:

2.1 The necessary analytical instrument and equipment, including the self-developed and domestically made equipment, except for those financed under the Second Account of the Common Fund.

2.2 Bulk raw and subsidiary materials and reagent consumed during experiment and development.

2.3 Water, electricity, etc. wage, administrative support and technical consultation required by R & D.

2.4 All local expenditure relating to organization, implementation, and technical exchange of this project.

2.5 The Chinese visiting group's travelling expenditure occurring in China.

3. Budget

Project budget for financing under the Second Account (unit: $US)

	Total	1992	1993	1994	1995	1996
Equipment	1,430,000	150,000	1,200,000	80,000		
Reagent, material	80,000	10,000	20,000	30,000	10,000	10,000
Mission cost	65,000	30,000	10,000	10,000		15,000
Duty travel	45,000	15,000	20,000		10,000	
Miscellaneous	30,000	10,000	5,000	5,000	5,000	5,000
Unpredictables	80,000			20,000	30,000	30,000
Total	1,730,000	215,000	1,255,000	145,000	55,000	60,000

Proposed Workplan & Implementation Schedule
(first and second year of the five-year project)

Content	1992												1993											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
1. Preparation of ultra fine WC powder																								
1.1 Selection of raw material	----	----	----	----	----	----	----	----	----	----	----	----												
1.2 Setting up plasma Lab		----	----	----	----	----	----	----	----	----	----	----	----											
1.3 Preparation of ultra fine powder by plasma													----	----	----	----	----	----	----	----	----	----	----	----
2. Passivation and storing technique for ultra fine powder																								
2.1 Passivation technique			----	----	----	----	----	----	----	----	----	----												
2.2 Storing technique			----	----	----	----	----	----	----	----	----	----												
3. Development of ultra fine-grained cemented carbide																								
3.1 Production process of mixed powders, selection of equipment														----	----	----	----	----	----	----	----	----	----	----
3.2 Compaction method, selection of equipment			----	----	----	----	----	----	----	----	----	----												
3.3 Optimizing sintering process			----	----	----	----	----	----	----	----	----	----	----											
4. Analytical and testing																								
4.1 Determination of grain size			----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
4.2 Research on grain size			----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----

PROJECT PROPOSAL 4 May 1991

Project Title

II. Development of rare earth doped cemented carbide and its mechanism research

Beijing, People's Republic of China

A. AIM AND SIGNIFICANCE

As the WC based cemented carbide is a kind of comparatively expensive material, its scope of application is limited to some extent. The rapid growth of world's economy shall lead to an increase in demand for cemented carbide and development of new application. Therefore it is necessary to look for a way of having a material with better property than the existing traditional cemented carbides while at same time without giving up the potential market of tungsten. The development of rare earth doped cemented carbide can achieve that purpose.

The cemented carbide, when doped with rare earth, will show an increase of TRS by 10-20%, and hardness by 0.5-1.0 HRA. What's more, it has low porosity and higher wear resistance. So there is important significance in bringing the performance of cemented carbide to full play, in reducing production cost and opening new field of application.

Research on the use of rare earth in cemented carbide was started in early 1960s, and was limited to grades rather than mechanism at that time in the world. So far, there is no rare earth doped cemented carbide to the market.

Some achievements have been obtained in China with regard to the use of rare earth in cemented carbide, there are a few grades of such products put into production. In terms of mechanism, it is found that addition of rear earth element to cemented carbide can imporve the physical properties of binding phase and performance of cemented carbide as a whole. It can be predicted that the doping of rare earth will significantly enhance the service life of cemented carbide. Further research into the effect of rare earth addition on wettability of hard phase and enforcing mechanism of binding phase shall be of help in promoting this project to a higher level.

The rare earth used as additive is usually light rare earth without radioactivity or radioactivity within allowance. So this project is not harmful to environment. The accomplishment of the project shall be helpful in making full use of tungsten resources, less investment yielding large profit. It is beneficial to promote.

B. OBJECTIVE AND OUTPUT

1. Development Objective

The overall objective of this project is to fully utilize tungsten resources, to improve the properties of existing grades, and to increase its ability to compete with substitution materials.

2. Immediate Objective

2.1 Addition of rare earth to the existing grades to develop rare earth doped cemented carbide.

2.2 Promote application
The emphasis of this project is laid upon the development of rare earth doped cemented carbide, research of proper kind of addition of rare earth element, its doping method and amount as well as enforcing mechanism.

3. Output

3.1 Four-year development of the project shall yield the following output:

3.1.1 On the basis of a slight increase in hardness, the durability of rare earth doped cemented carbide can be doubled with an increase in TRS by 10-20%.

3.1.2 The increase in tool life of rare earth doped cemented carbide can reduce tool wear, tool exchange time, tool cost; enhance machining efficiency and quality; decrease machining cost, thus leading to substantial social benefit.

3.1.3 The technology for the production of new rare earth doped cemented carbide can be transferred gratis to States members of the Committee on Tungsten, which is of help to develop new series of cemented carbide.

3.2 Output of 1992

3.2.1 The competent authorities and department undertaking this project shall evaluate the production process of the development of rare earth doped cemented carbide, and reach an agreement.

3.2.2 At least there shall be 3 personnel who have a good understanding of the progress plan and research direction of this project. In addition, they should be able to conduct technical exchange activities at home and abroad.

3.2.3 Presenting a stage research report on the proper kind of rare earth additives, its doping method and amount.

C. MAIN RESEARCH ACTIVITIES

The following activities shall take place between 1992-1995.

1. Research on the proper kind of rare earth additive, its doping method and amount;

2. Research on the microstructure and wettability of rare earth doped cemented carbide;

3. Determine process parameter for pilot experiment; complete designing of rare earth doped cemented carbide grades;

4. Investigate the on-site application condition; tool wear characteristics in the field of cutting, rock-drilling and wear; present a evaluation report on its technology and economy;

5. Promote application so as to form production on industrial scale;

6. Present a report on development and its mechanism research.

D. PROJECT INVESTMENT

This project requires foreign currency totalling $US 840,000.

1. Financing under the Second Account of the Common Fund

1.1	Equipment		
	50 KW vacuum sintering furnace	$US	90,000
	Small vacuum carburizing furnace	$US	70,000
	Vacuum induction smelting furnace	$US	75,000
	Wettability analyzer (computer-controlled)	$US	50,000
	Energy dispersive X-ray analysis system	$US	200,000
	Wire-cutting machine	$US	250,000
	Subtotal:	$US	735,000
1.2	Reagent, material (special reagent for testing, and accessories)	$US	20,000
1.3	Mission cost (project evaluation etc.)	$US	25,000
1.4	Duty travel (literature survey and selection of equipment)	$US	15,000
1.5	Miscellaneous (communication etc.)	$US	15,000
1.6	Unpredictable (5%)	$US	30,000
	Total	$US	840,000

2. Investment by People's Republic of China

Investment by the China National Non-ferrous Metals Industry Corp. includes:

2.1 Necessary equipment and analytical instrument for the project, except for those financed in foreign currency under the Second Account;

2.2 Bulk raw & subsidiary materials for R & D;

2.3 Consumption of power, wage, administrative support and technical consultation;

2.4 The Chinese visiting group's travelling expenditure occurring in China.

3. Budget

Financing under the Second Account of the Common Fund (unit: $US)

	Total	1992	1993	1994	1995
Equipment	735,000	400,000	300,000	35,000	
Reagent, material	20,000			10,000	10,000
Mission cost	25,000	15,000			10,000
Duty travel	15,000	5,000	10,000		
Miscellaneous	15,000		5,000	5,000	5,000
Unpredictable	30,000		10,000	10,000	10,000
Total	840,000	420,000	325,000	60,000	35,000

Proposed Workplan and Implementation Schedule
(1992-1995)

Content	1992				1993				1994				1995			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1. Addition of rare earth																
1.1 Proper kind of addition	----------															
1.2 Addition method		------														
1.3 Addition amount			---------													
2. Microstructure and wettability				----------												
3. Pilot test, optimization of parameter																
4. Complete grade designing					----------											
4.1 Small batch production						----------										
4.2 On-site test							----------									
5. Perfection of process												----------				
6. Promote application																----------

PROJECT PROPOSAL 4 May 1991

Project Title

III. Development of the new process for heat-treatment of cemented carbide and its application

Beijing, People's Republic of China

A. AIM AND SIGNIFICANCE

The final main use of tungsten is to produce cemented carbide. During its practical application of inserts and tips, there usually occurs early chipping or wear, because its toughness and wear resistance cannot be well combined. For many years, every effort has been made to have a high performance cemented carbide with a good combination of wear resistance and toughness. Heat-treatment of cemented carbide is a simple and efficient way. It is found out that change in binding phase and structure by heat-treatment can increase toughness. In this sense, there is important practical significance in revealing the re-enforcing mechanism of cemented carbide by heat-treatment, investigating the optimum condition of heat-treatment, in developing new series of heat-treated cemented carbide with well combined properties, in widening its application scope, and in enhancing its ability to compete with other substitution materials.

The possibility of heat-treatment of cemented carbide was presented as early as 40 years ago. Such research was conducted in Soviet Union, Sweden in the 1960s, failing to achieve practical purpose. In mid 1980s, China began research on heat-treatment of WC-Co alloy for mining tools. It is shown by practical use that the occurrence of chipping is obviously reduced with an increase in drilling efficiency and a decrease in drill and mining cost. However, further effort is still required into research on the heat-treatment of cutting inserts, drawing and forming dies, and wear parts.

The project is estimated to be completed within 4 years (1992-1995)

There will not occur any toxic gas or liquid during the process of heat-treatment, so, it does not harm the environment.

This project is aimed at the improvement of cemented carbide performance, which is of help for the tungsten-consuming countries to increase work efficiency, reduce processing cost, further develop and stabilize the tungsten market.

B. OBJECTIVE AND OUTPUT

1. Development objective

The overall objective of this project is to improve the cemented carbide performance as a whole, to widen its application, and fully utilize the tungsten resources.

2. Immediate objective

2.1 Research on the heat-treatment condition for the > 8% Co cemented carbide; on the mechanism of Co phase re-enforcement and toughness of cemented carbide.

2.2 Research on the heat-treatment condition of < 8% Co cemented carbide; on the possibility of toughening low Co cemented carbide and achievable degree of commercializing the heat-treated low Co cemented carbide.

2.3 Research on the failure characteristics of heat-treated cemented carbide tools in practical use in order to determine the limit of condition in application.

3. Output

3.1 The following output shall be achieved for the project within 4 years after it is put into action.

3.1.1 Development of a series of new heat-treated cemented carbide, new production process. Research achievements can be transferred gratis to States members of the Committee on Tungsten.

3.1.2 Failure rate of the heat-treated non-brazed tools shall be decreased by 50% with double service life.

3.1.3 The TRS of heat-treated >8% Co WC-Co and WC-TiC-TaC-Co alloys shall be increased by 10-30% with double durability.

3.1.4 Research on the heat-treatment of <8% Co cemented carbide so as to determine the commercialization possibility; present an evaluation report.

3.1.5 With the improvement in product properties, the heat-treated cemented carbides can be substituted for some cemented carbides with special properties, providing a wide range of choice for consumer. The increase in durability can reduce tool cost for customers and increase working efficiency. It is helpful for the economic development of the Third World countries.

3.2 Output of this project for 1992

3.2.1 Evaluation shall be conducted on the production process of the heat-treatment of cemented carbide by the competent authorities and departments undertaking this project; an agreement shall be reached.

3.2.2 The four-year R & D workplan shall be drawn out, covering the development of quenching furnace, heat-treated cemented carbide, promotion and application, achievements evaluation.

3.2.3 Development of vacuum sintering-quenching furnace, which is useful for the development of heat-treated cemented carbide.

3.2.4 At least, there are 2 personnel who will have a good idea about the progress and research direction of the project, and able to conduct technical exchange at home and abroad.

C. MAIN RESEARCH ACTIVITIES

1. For realization of the overall objective, the main research activities are as follows:

1.1 Relation between the change in property and structure under different heat-treating condition.

1.2 Different quenching method and its effect.

1.3 Critical quenching and cooling speed for the heat-treatment of cemented carbide with different composition and structure.

1.4 Influence of various brazing method and brazing condition that are detrimental to the heat-treatment effect.

2. The four-year research project shall be completed through a series of extensive technical research and cooperation; development of the new process for direct quenching after sintering; and new grades for mining and cutting purpose. e.g.:

2.1 Optimization of process parameters for heat-treatment.

2.2 On-site comparative test for heat-treated cemented carbide for mining and cutting.

2.3 Mechanism of heat-treatment process.

3. Activities of 1992-1993

3.1 Detailed literature survey and extensive technical exchange shall be carried out based on the objective, research plan shall be made after analysis and evaluation.

3.2 Optimization of the process parameters for heat-treatment of WC-Co Systems.

3.3 Research on the microstructure of heat-treated WC-Co systems

3.4 On-site performance test for heat-treated WC-Co systems

3.5 Research on the heat-treatment process for WC-Co-TiC (NbC.TaC) systems

During the next month following the approval of this project, the Ministry of Foreign Economic Relations and Trade and China National Non-ferrous Metals Industry Corp. together with Zhuzhou Cemented Carbide Works and personnel concerned shall meet to finalize the task, objective and workplan.

Upon definition of the task, department and personnel concerned shall, within 3 months, complete organization and work out practical plan, optimize literature survey, determine process route, and conduct overseas technical exchange.

Detailed workplan and schedule are listed in the attachment. The objective plan for 1994-1995 shall be made in the fourth quarter of the second year after this project is started, meanwhile a stage summary report will be presented.

1992: Present investigating report and work plan
1993: Present development report on the heat-treatment of WC-Co systems
1995: Present development report on the heat-treatment of WC-Co-TiC (NbC.TaC) systems

D. PROJECT INVESTMENT AND BUDGET

This project requires foreign currency totalling $US 1.33 million.

1. Financing under the Second Account of the Common Fund.

1.1	Equipment		
	Vacuum sintering-quenching furnace	$US	100,000
	X-ray diffractometer	$US	450,000
	Electronic probe	$US	500,000
	subtotal	$US	1,050,000
1.2	Reagent, material (special material, spare parts of instrument)	$US	100,000
1.3	Mission cost (project formulation, monitoring and evaluation)	$US	50,000
1.4	Duty travel (literature survey and selection of equipment)	$US	40,000
1.5	Miscellaneous (communications etc.)	$US	30,000
1.6	Unpredictable (5%)	$US	60,000
	Total	$US	1,330,000

2. Investment by People's Republic of China

Financial investment by China National Non-ferrous Metals Industry Corp. includes:

2.1 Necessary equipment and analytical instrument except for those financed in foreign currency under the Second Account.

2.2 Bulk raw and subsidiary materials and reagent consumed during the execution of the project.

2.3 Water, electricity and wages, etc.

2.4 All local expenditure relating to the project; the Chinese visiting group's travelling expenses occurring in China.

3. Budget

Budget for the Financing under Second Account

Unit: $US

	Total	1992	1993	1994	1995
Equipment	1,050,000	630,000	370,000	50,000	
Reagent, material	100,000	40,000		20,000	40,000
Mission cost	50,000	20,000	10,000		20,000
Duty travel	40,000	20,000		20,000	
Miscellaneous	30,000	10,000	5,000	5,000	10,000
Unpredictable	60,000		10,000	25,000	25,000
Total	1,330,000	720,000	395,000	120,000	95,000

Proposed Workplan and Implementation Schedule (1992-1993)

Content	1992												1993											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
1. WC-Co systems																								
1.1 Optimization of process parameters																								
1.1.1 Quenching and tempering						----------																		
1.1.2 Selection of quenching method	----------																							
1.1.3 Minimum speed for strengthening and toughening																----------								
1.2 Research on microstructure of heat-treated alloys						----------																		
1.3 On-site test																----------								
2. WC-Co-TiC(TaC-NbC)																								
2.1 Research on heat-treatment process												----------												
3. Development of vacuum sintering-quenching furnace	----------